Feature

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Sharing is caring

Electronic support measures play their cards

Electronic support measures systems have a vital role to play detecting hostile ships and near-surface threats like sea-skimming anti-ship missiles as they can often discern such threats at longer ranges than a ships' own radar.

The physics bit

This is because electronic support measures (ESM) need only detect the relatively stronger power of the pulse of radio frequency (RF) energy transmitted by the hostile radar. A radar on the other hand must detect the much lower power echo of the pulse as it is reflected by the target back to the antenna. For targets at the outermost reaches of the radar's range, the returned echo will be so weak that it can disappear in the prevailing electromagnetic noise constant in Earth's atmosphere. ESM systems do not have this problem as all they need detect is the incoming radar pulse which may retain its strength beyond the radar's instrumented range. The instrumented range is the maximum distance at which a target with the minimum radar cross section detectable by the radar can be detected and tracked at all altitudes and speeds.

A deployed task group may have tens of warships occupying hundreds of nautical miles, yet at best each of these will only be capable of detecting radar and radio signals from other warships at ranges tens of nautical miles from their ESM receivers – this risk leaving vast swathes of ocean unmonitored for electromagnetic threats. It may also mean that ships only detect threats once they are a relatively short distance away. This is particularly worrisome *vis-à-vis* anti-shipping missiles. As Naval Forces has chronicled on many occasions, a new breed of anti-ship missiles are entering service or under development that can attain hypersonic speeds of up to eight times the speed of sound; 9,879km per hour, with Russia's NPO Mashinostroyeniya 3M22 Zircon (NATO reporting designation SS-N-33) being an instructive example. Assuming that an incoming 3M22 was travelling at a sea-skimming altitude at Mach 8, a quick calculation

A key feature of the L3Harris ES-3701S precision radar electronic support measures suite seen here carried by the Swedish Visby class stealth corvette HSwMS Helsingborg (K 32) is the system's ability to provide complete radio frequency coverage with direction finding from communication through radar bands. (Photo: Royal Swedish Navy) reveals that the crew of the 'The Big Stick' would have at best around 13 seconds to take evasive action against the missile if it is to be detected at the estimated maximum range of the carrier's ESM.

There is clear merit in detecting electromagnetic threats down range as soon as possible, but how to do this when an ESM system's detection range for surface-based and sea-skimming threats can be limited by the range of the radio horizon? Networking the ESM systems and radar warning receivers (RWRs) equipping the ships and aircraft of a task group is one solution. Those assets closest to the sources of the hostile emissions will be the first to detect them. They can then share this information with the rest of the task group and those ships and aircraft which do not yet have these emitters in ESM detection range.

This serves two purposes: It advises the task group of potential threats not yet in range of some assets, but within ESM detection range of others. The former is forewarned and can potentially come to the aid of the latter if required. Secondly, this information helps contribute to a rich electronic order-of-battle (EORBAT). One handy trick of an ESM is that it can potentially identify a vessel or aircraft based upon its radar emissions. ESM systems are programmed with parameters of friendly and hostile radars derived from electronic intelligence (ELINT) collection. These parameters will enable the ESM to match certain radar transmissions with certain vessels or aircraft.

For example, the Thales UAT Mod 2.1 radar ESM suite outfitting a Royal Navy Type 45 (Daring class) destroyer may indicate that it has detected radar emissions from a Saab Sea Giraffe AMB C-band (5.25GHz to 5.925GHz) naval surveillance radar which the ship's electronic warfare personnel correlate with the Royal Swedish Navy's Visby class corvette accompanying their task group. Similarly, the UAT Mod 2.1 may detect S-band (2.3GHz to 2.5GHz/2.7GHz to 3.7GHz) transmissions matching the parameters of an Agat Fregat-M2EM (NATO reporting name Top Plate) naval surveillance radar that equips Russian Navy's Neustrashimyy class (Projekt 11540) frigates. This may indicate that potentially hostile ships are nearby. This also helps contribute to the general ORBAT of friendly and hostile forces.

What is more, this can be done passively without having to use the radar, and can be achieved at longer detection ranges.

CESMO

By networking naval ESM systems, it becomes possible to determine the location of hostile emitters by combining collected ELINT. This is the philosophy at the heart of NATO's Cooperative Electronic Support Measure Operations (CESMO) initiative. CESMO uses the principle of time difference of arrival, or TDOA, to determine where a hostile radar is located.

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TDOA uses triangulation and the handy fact that RF energy travels at the speed of light. Let us assume that our Projekt 11540 frigate is traveling on a south-to-north bearing; 30nm (56km) northeast of the ship is a Type 45 destroyer; 20nm (37km) to the south of the Russian frigate is a Nimitz class carrier; and 15nm (28km) to the east of the Russian ship is a De Zeven Provinciën class frigate of the Royal Netherlands Navy. The ESM systems on all three vessels are detecting the transmissions from the Russian frigates' Fregat-M2EM radar and are identifying it as such. These transmissions take 0.18 milliseconds to reach the ESM suite fitted to the Royal Navy destroyer, 0.09 milliseconds to be detected by the carrier's Raytheon AN/SLQ-32(V)4 ESM and 0.12 milliseconds to reach the Thales Vigile-D ESM outfitting the Dutch frigate. Given that these ESM systems can also determine the bearing of the signal from the Russian ship, by using some standard high school trigonometry we can determine that the radar, and

hence the ship, is located at the point where the bearings from each ship's ESM converge. The idea behind CESMO is for each air or sea assets supporting a deployed naval force to turn the ELINT gathered by each asset's ESM and/or RWR into operational situational awareness information. The ELINT is turned into IP (Internet Protocol) data and transmitted over standard high frequency, very/ultra high frequency (V/UHF; 30MHz to 3GHz) and satellite communications (SATCOM). This information ends up at the CESMO fusion and coordination (CFC) node. The CFC is a computer that hosts the CESMO software. Building CESMO around IP traffic was an adroit move by NATO: "The utilisation of IP makes CESMO future proof since it can be used by any future data-link or infrastructure network" capable of handling IP traffic, noted Marco Mehling, operational requirements manager for Airbus' Eurofighter future businesses division.

Using our above example of the Russian frigate, the CFC would receive IP-formatted ELINT from the three ships. The software would determine that all three ESM suites are in fact detecting the same radar. The software would take the respective bearing and distance information provided by the ESM systems and triangulate the location of the radar. With the radar, and hence the Russian frigate's location determined, the CFC would send this information back out across the CESMO network letting all participants know that there is a Fregat-M2EM radar belonging to a Russian Navy Projekt 11540 frigate at this particular location. This information will be continually updated as the ESM equipment provides new information on the radar's distance and bearing as the frigate moves through the ocean. With the location of the Russian frigate now being shared with the naval assets supporting the task group, commanders can take the decision whether to engage the offending radar kinetically or electronically or leave it in peace.

Links on the brink

CESMO "was originally designed to find, fix and track threats in the electromagnetic spectrum by the collaboration of assets from multiple domains" to support an array of joint operations, Marco Mehling suggested. The initiative gathered momentum in 2015 when NATO ratified Standardisation Agreement-4658 (STANAG-4658). STANAG-4658 laid down the stipulations for the CESMO architecture and protocols. One of CESMO's key attractions is that new communications networks are not needed to handle the all-important IP data carrying ELINT between assets, and to and from the CFC. This makes the protocol highly applicable to the maritime space.

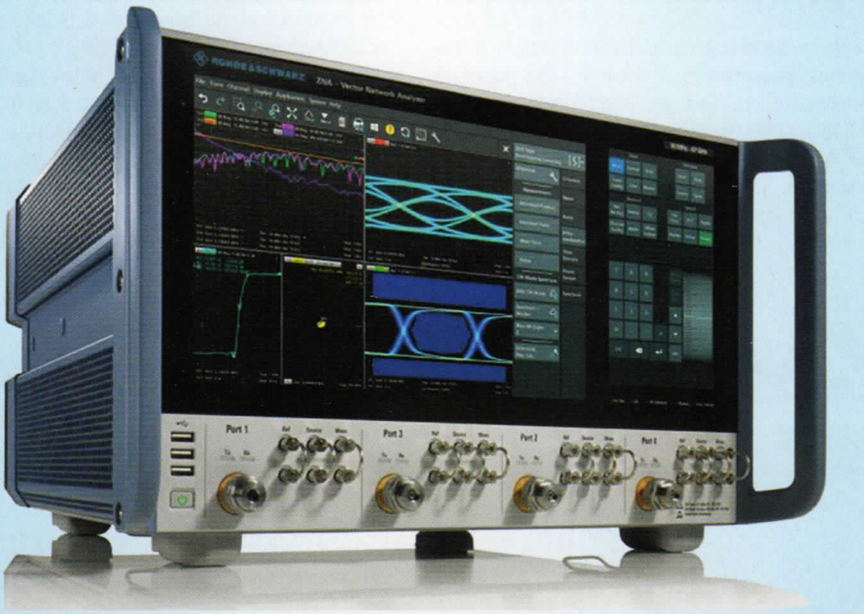
"You can use the same architecture in the maritime space that you can in the air domain," Peter Ellis, principal engineer for Curtiss Wright, noted. The company produces the HUNTR tactical data-link hub and network translator that facilitates communications between disparate protocols. For instance, HUNTR allows an aircraft using the NATO and allied Havequick I/II UHF air-to-surface/surface-to-air radio waveform to talk to another aircraft without Havequick I/II-compatible radios, but which can handle the NATO/allied Link-16 (960MHz to 1.215GHz) tactical data-link protocol mainly used to support air operations. The STANAG is very important as it provides NATO members all the instructions and directions necessary to implement CESMO.

Captain René Raden from the German Air Force, also CESMO team lead at the NATO Signals Intelligence and Electronic Warfare Working Group, said that, "The STANAG has all the required data fields." Beyond this, he said that the only other aspect which needs drafting are the tactics, techniques and procedures for using CESMO in the naval environment.

"The technology of CESMO is applicable to any situation where you have location bearings that you need to share," Peter Ellis observed. Such a need is as acute in the maritime domain as in the air: "You use the same architecture for the naval context and CESMO lends itself to all platforms," he continued. The CESMO architecture is 'box ready' for use in this context: "CESMO does not need to be adapted, and was designed from the very beginning to support naval operations," Marco Mehling declared. For instance, the CFC could be onboard one ship, with a back-up on a second.

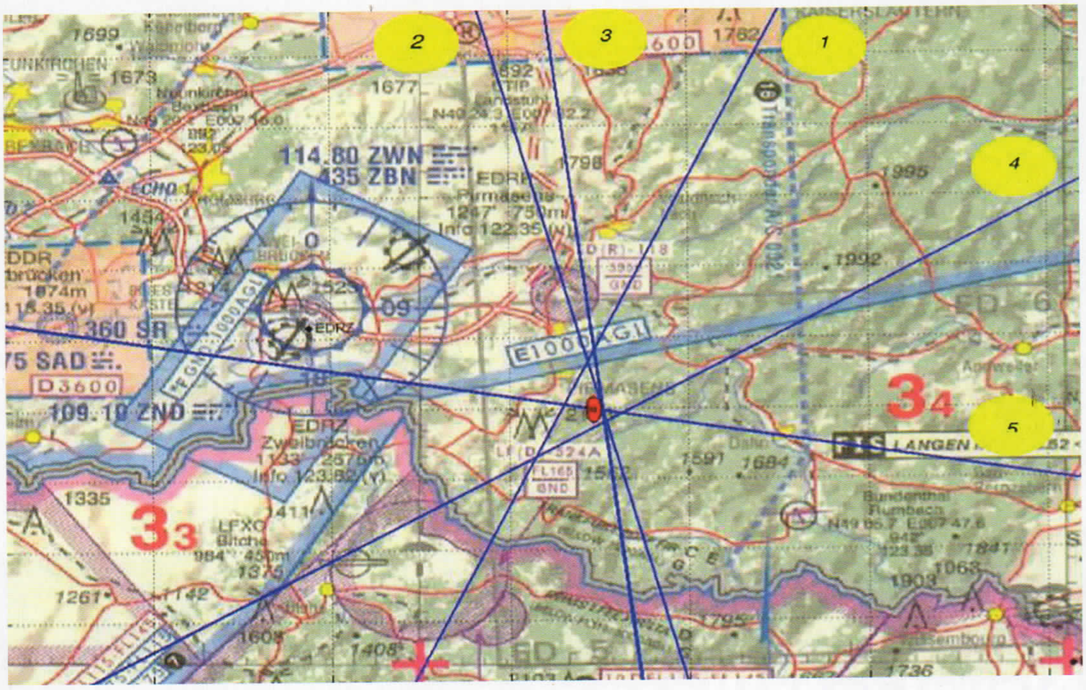
Many readers will be aware that Link-16, along with the Link-11/22 NATO and allied TDLs using frequencies of 2MHz to 29.9MHz and 225MHz to 399.975MHz can convey EW information across their networks. Peter Ellis commented that these TDL terminals can be expensive to procure and install, and not every platform in a task group might be equipped with them. CESMO, on the other hand, only shares emitter location information and thus lifts some of the EW messaging burden from these high-demand TDLs: "CESMO does all the EW information crunching and then spits

New analysers with capability to 67 Gigahertz



Covering the 5G and 6G frequency bands, the ZNA is a future-proof solution for research on active and passive components such as filters, antennas and mixers. (Photo: Rohde & Schwarz)

Rohde & Schwarz revealed the latest version of its ZNA high-end vector network analyser (VNA), featuring a frequency range up to 67GHz, on 7 April. This means the VNA range now includes models with 50GHz and 67GHz maximum frequencies, opening up performance to new areas of operation. Signal integrity measurements as well as aerospace/defence and 5G component/module characterisation are the principal applications for the new analyser models; the ZNA is, according to the manufacturer, the world's first purely touch-operated VNA, and features excellent RF performance, including a wide dynamic range and extremely low trace noise. It comes with a user-friendly, touch-based GUI (graphical user interface), and its unique hardware platform offers up to four internal, phase-coherent sources, plus a fifth source that can be used as a second internal local oscillator or as an additional source for measurements on mixers. In combination with up to eight parallel measurement receivers, the ZNA hardware architecture is ideal for demanding measurements on components and modules, according to Rohde & Schwarz.



This diagram illustrates how disparate electronic support measures mounted on aircraft help triangulate the position of hostile emitters. (Diagram: NATO)

out something that you could then put on the TDLs so that you do not overload these data-links," Ellis said.

To access TDLs like Link-11/22 or Link-16 aircraft, ships and shore installations need dedicated terminals, whereas access to a CESMO network requires the platform's standard radios, cryptography and a hardware or software modem. "Load the crypto, dial up the radio and you are on the CESMO network," said Ellis. As Captain Raden added, one of CESMO's strengths is that it is 'box ready' for use, unlike the significant planning that has to go into establishing a TDL network. This is because, "traditional TDLs are built for the operational picture and not for the process to produce this picture," he said; thus "they need a lot of infrastructure, preplanning and administration." Using the CESMO network to handle ELINT also ensures that TDLs, which are always in high demand, are not overtaxed with handling additional traffic, Mehling noted, adding that, "One of the philosophies currently employed is to use CESMO messages [to] only report the actual position of an emitter in the form of a track into Link-16. That way, CESMO is complementary to Link-16" without adding too much traffic to the network.

HUNTR can help by taking the information being shared on a CESMO network and translating it into a format handled by these TDLs. Peter Ellis articulated that the German Air Force is using HUNTR and the German Navy and has shown interest in using CESMO. As Captain Raden described, one of CESMO's strengths is that "it is not matter of the data-link, it is a matter of the specific use case you want to implement," he said, adding that CESMO "gives you the flexibility to fulfil your task, and share [information] with every involved platform."

Let's rock!

Peter Ellis clarified that a CESMO network can get slowed down if there are too many participants, but one way to avoid this would be to have separate CESMO networks for air and naval assets supporting a task group, ensuring that networks are not overburdened. Simplicity is key. The last thing that sailors and aircrew want is something that is complex and capricious to establish and maintain. CESMO is attractive as it is easy to activate and use.

"You can join every CESMO subnetwork if you have the right frequency and crypto key. This allows a much more flexibility, and the most significant advantage of CESMO is that it is IP-based," he put forward.

Importantly, CESMO will not replace TDLs for the carriage of EW information and neither is it intended to. "CESMO is built for a special use case, to rapidly share data over a limited bandwidth and to identify and locate emitters which are possible threats," Ellis mentioned. CESMO is particularly useful for "assets that do not possess any of the 'traditional' data-links such as Link-11/22 and Link-16," voiced Marco Mehling.

As well as sharing this information over the TDL networks, gateways like HUNTR can take relevant emitter information from the CESMO network and share it with other users who may need it using TDLs. In both cases, using the CESMO network to share ELINT and emitter locations amongst assets when relevant and required via gateways across other networks provides an all-important "significant contribution to the common operating picture," Captain Raden expressed. Complementarity not competition is the watchword and CESMO is showing promise as an easy-to-implement, cost-effective arrow in the naval situational awareness quiver. After all, sharing is caring! NAFO

Situational awareness is vital in electronic warfare, although many electronic support measures sensors are often limited to a relatively short range; CESMO can extend their detection ranges by networking assets. (Photo: Rohde & Schwarz)